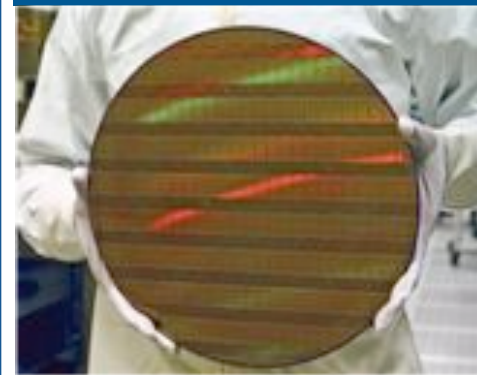# inpria

## creating solutions

# Imageable Oxides:
# New Solutions for Resist

Jason Stowers, Alan Telecky,
Andrew Grenville
October 20, 2010

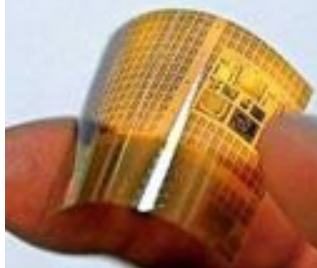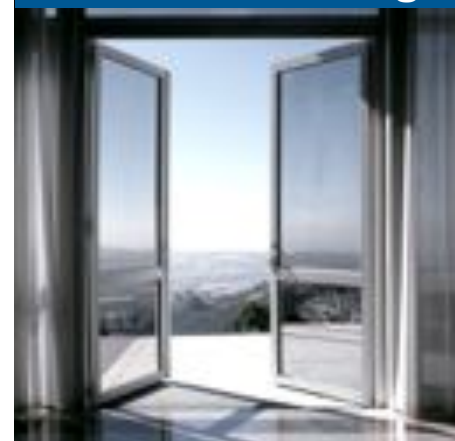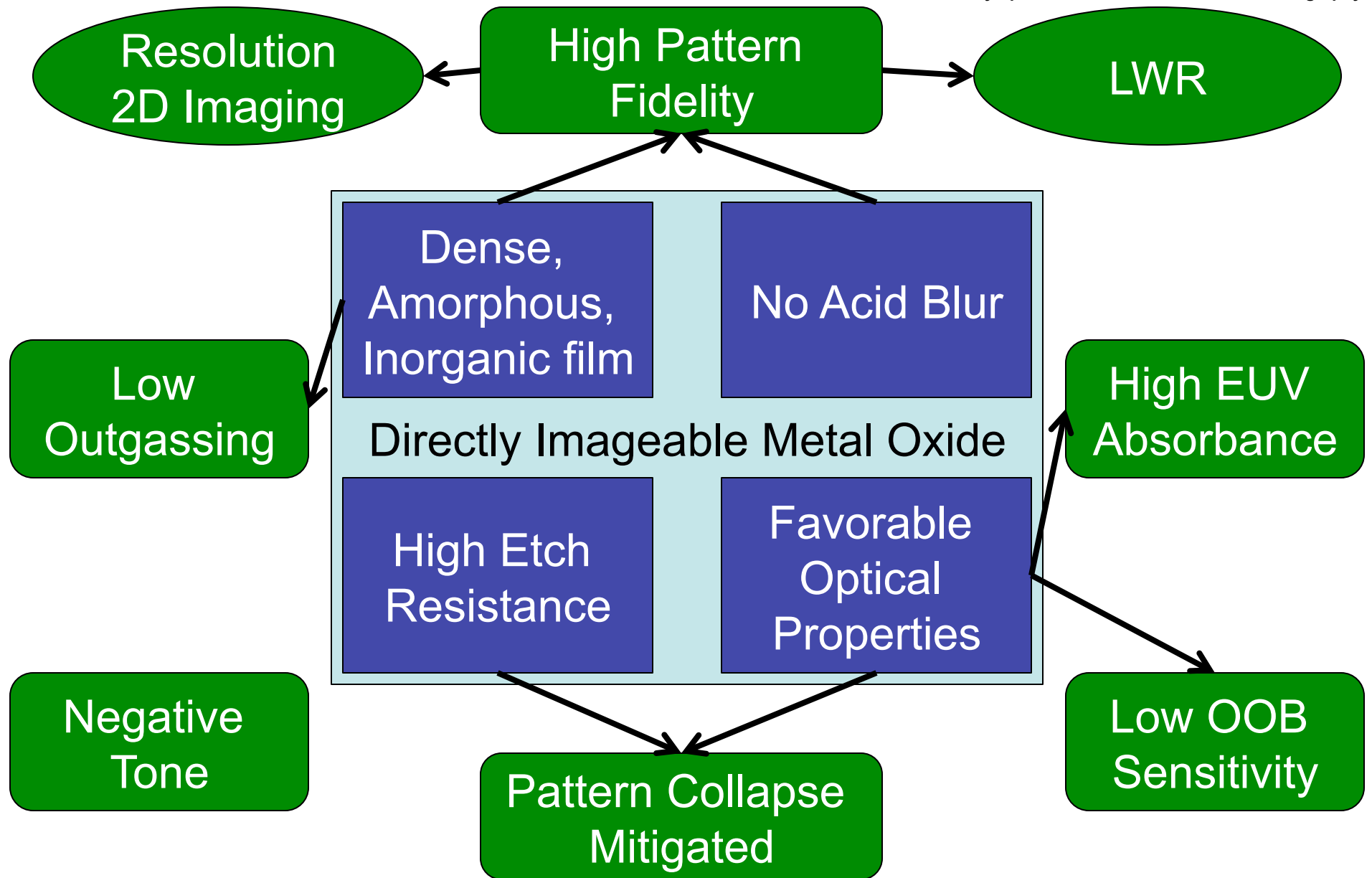**Display Backplane TFT Materials**

**Lithography Resist**

**inpria**

**Materials And Processes**

**Thin Film PV**

**Printed Electronics**

**Window Coatings**

inpria

Resolution 2D Imaging

High Pattern Fidelity

LWR

Low Outgassing

Dense, Amorphous, Inorganic film

No Acid Blur

High EUV Absorbance

Directly Imageable Metal Oxide

High Etch Resistance

Favorable Optical Properties

Negative Tone

Low OOB Sensitivity

Pattern Collapse Mitigated

inpria

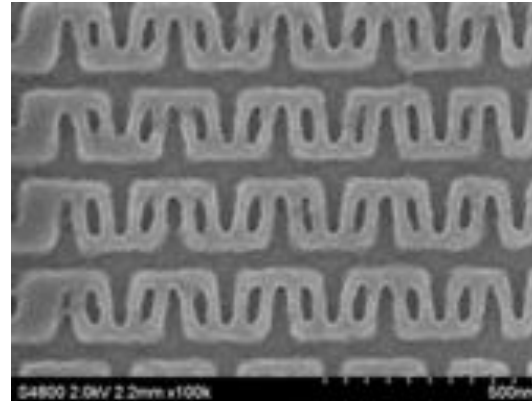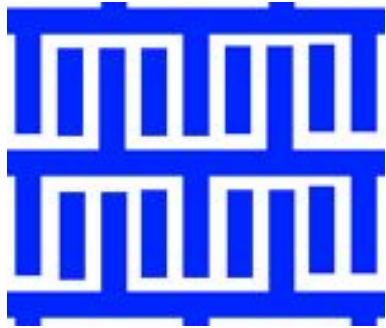# Pushing LBNL MET Resolution



16nm hp

15

14

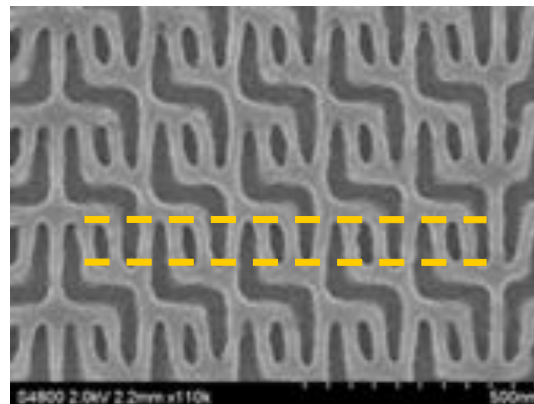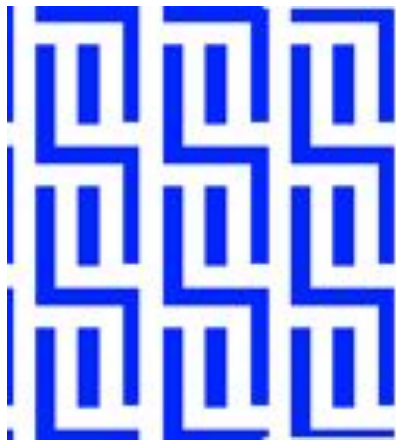13.5

13

12.5
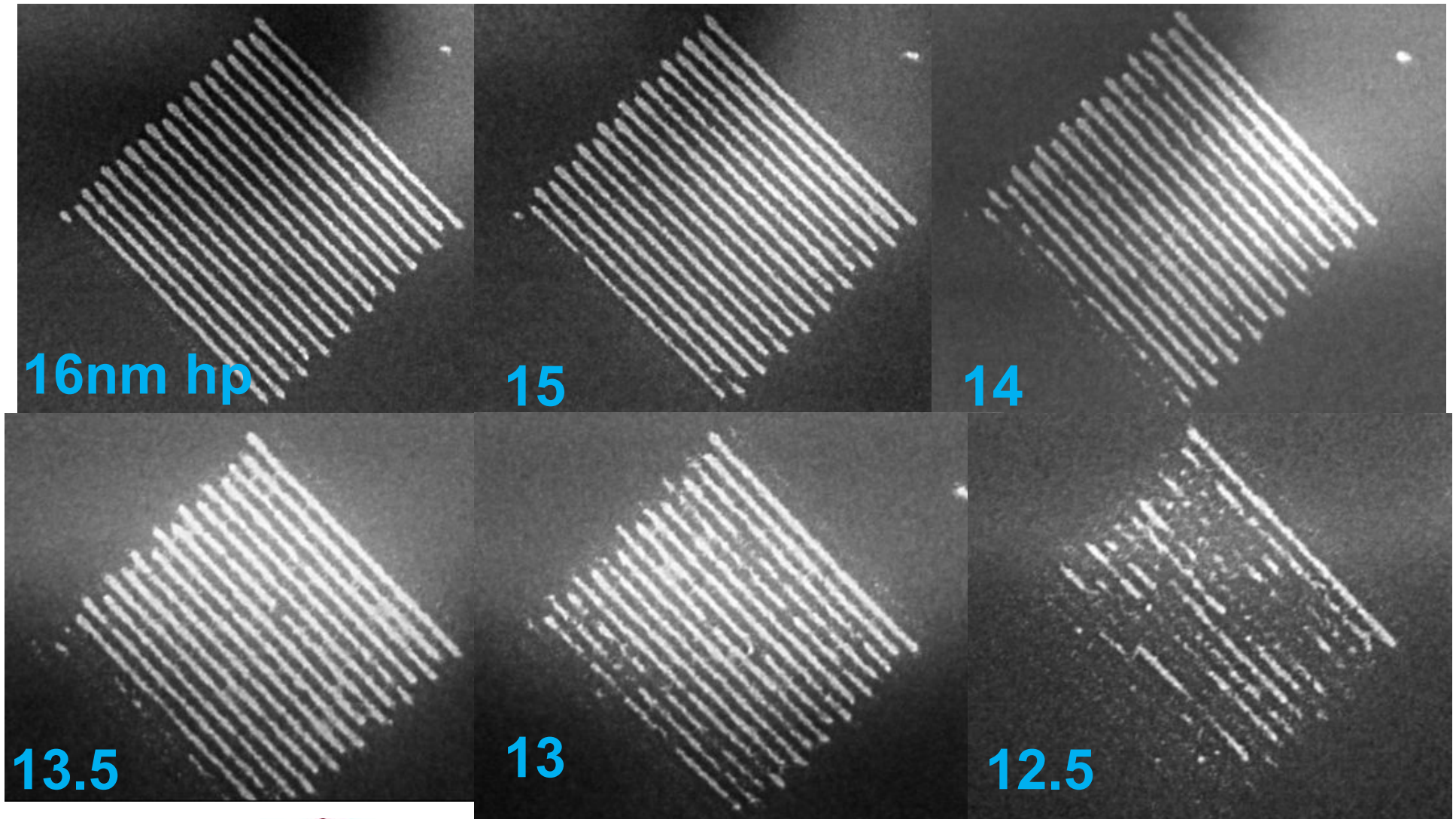
LBNL F2X imaging, ~70 mJ/cm$^2$

Data courtesy Patrick Naulleau, Chris Anderson LBNL

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# 2D Pattern Fidelity

Mask Representation



32 nm HP
'Ts'
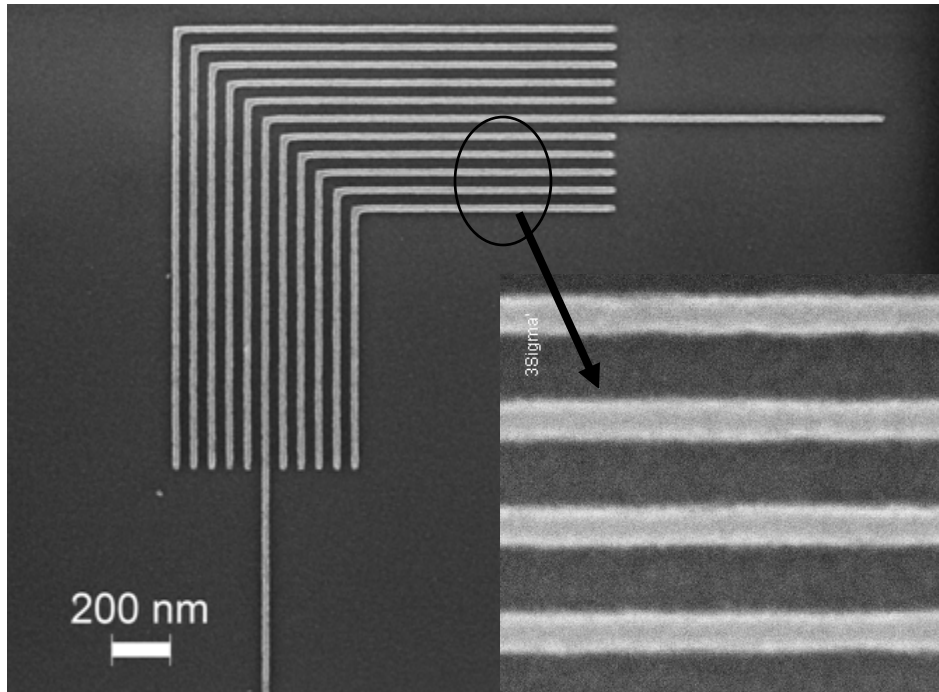(2 pitch)
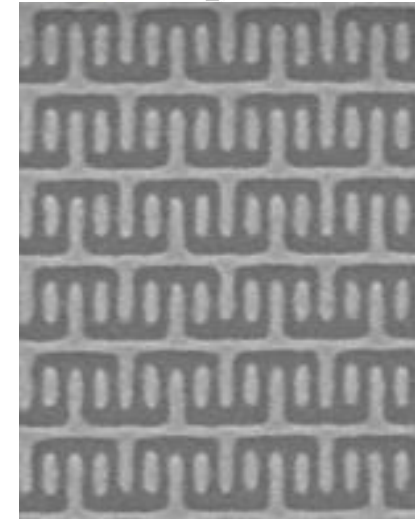


Conventional
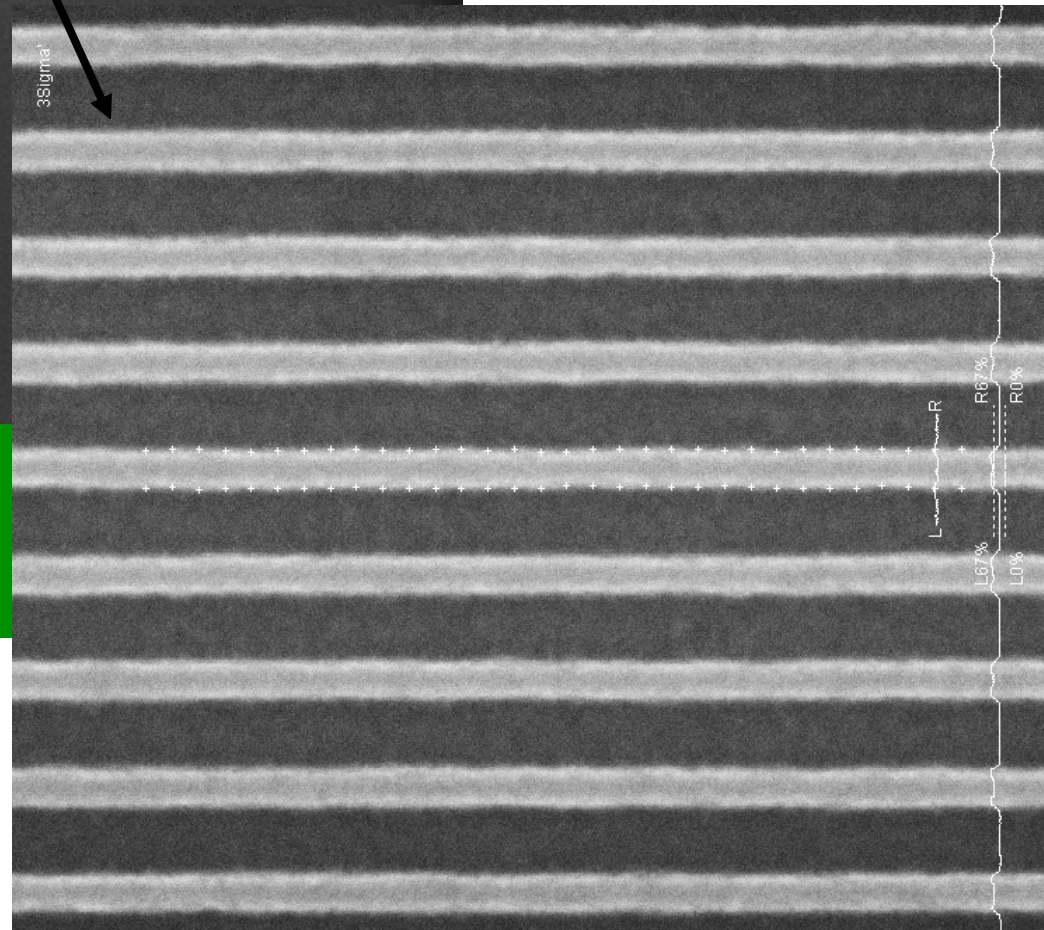Resist (pCAR)

32 nm HP
jogs
(2 pitch)

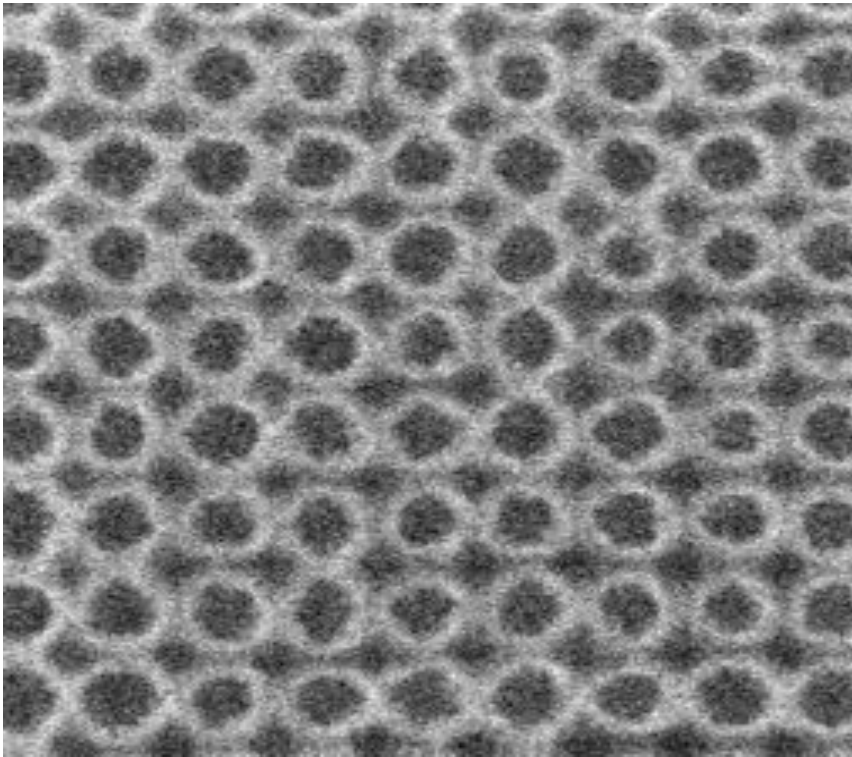# Low LWR (by e-beam)



LWR 1.6-1.8 nm
CD 21 nm, 60 nm pitch
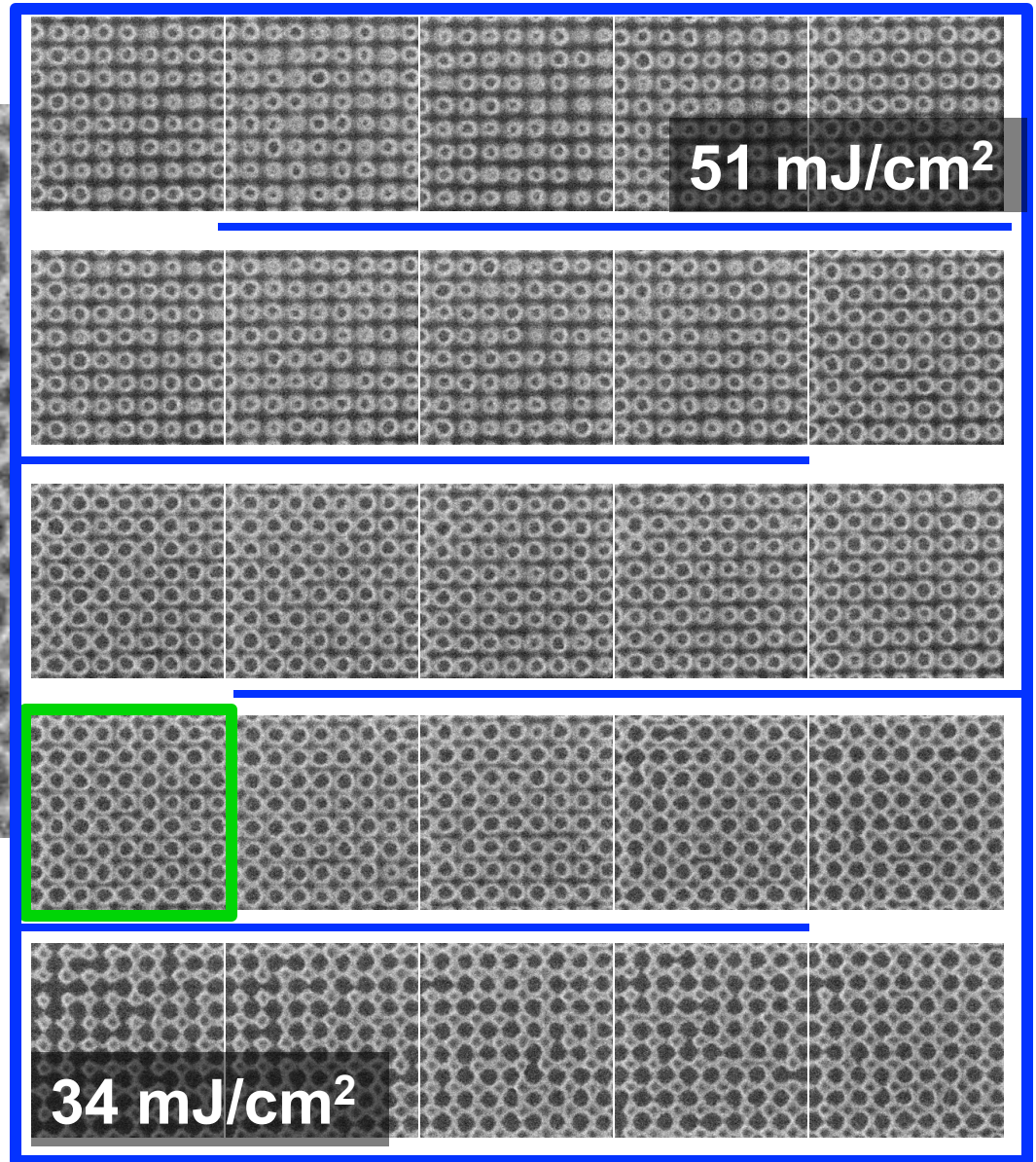30keV EB, 436 µC/cm$^2$

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# 32 HP Contact Holes on IMEC ADT



32nm half-pitch, 40 mJ/cm$^2$

Note: *dose meander only,* 25% TMAH

51 mJ/cm$^2$

34 mJ/cm$^2$
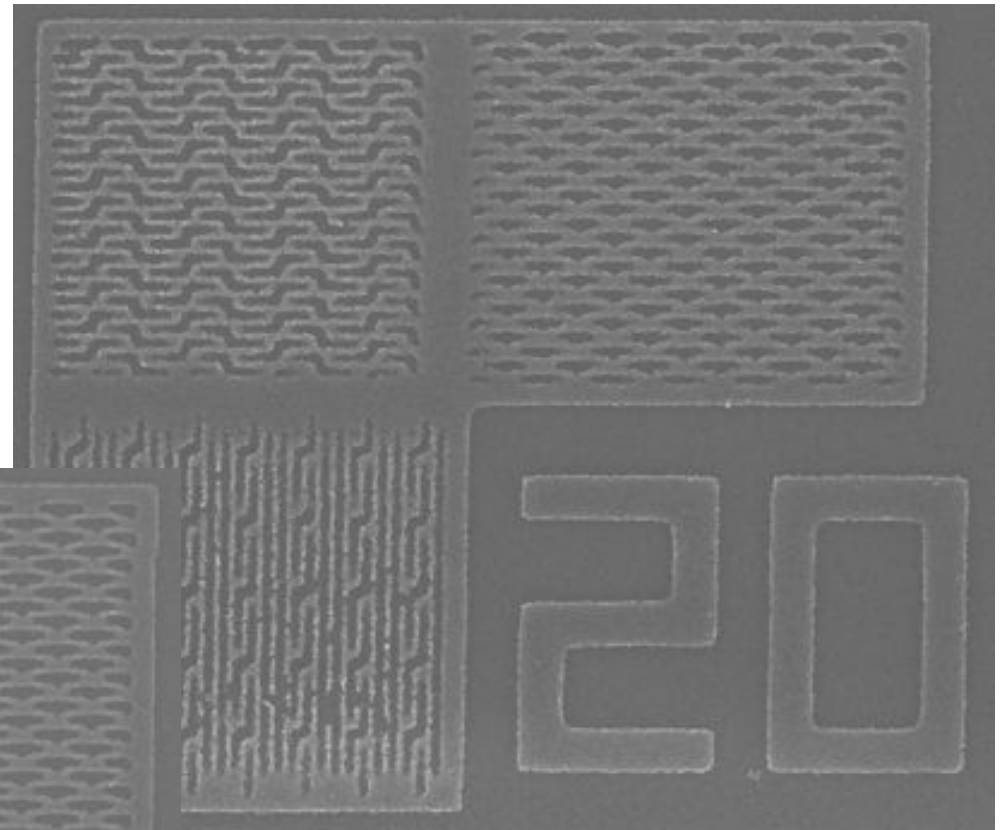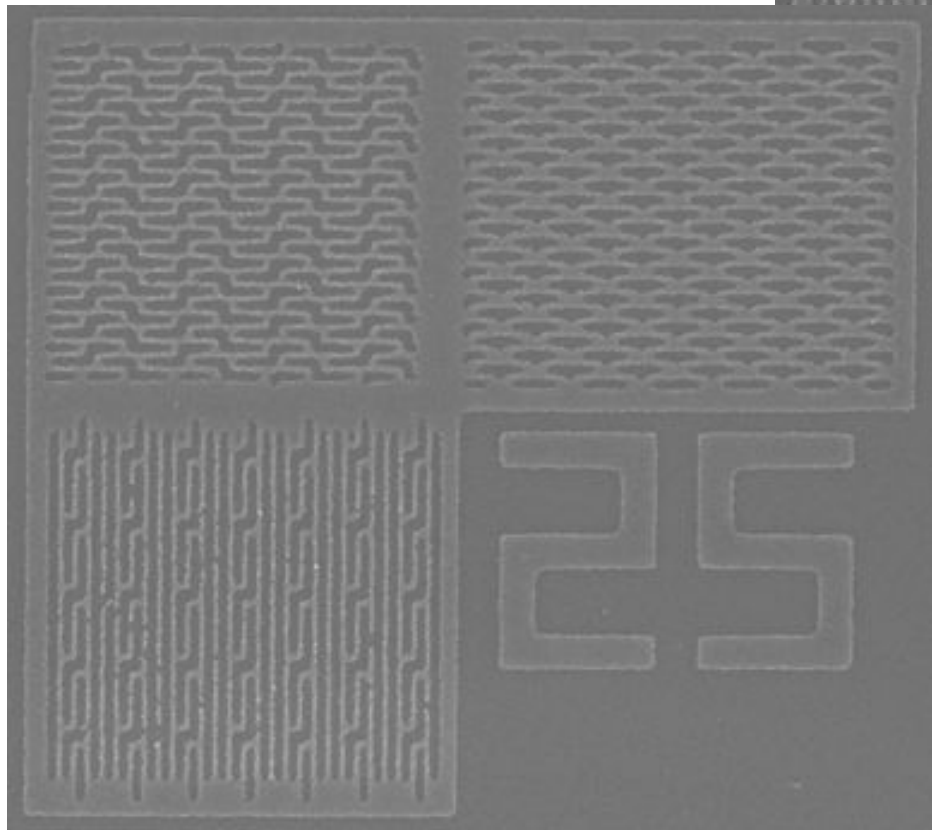
Courtesy Roel Gronheid, IMEC

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# Resolution

- 20nm HP <u>Annular Illumination</u>
- 56 mJ/cm$^2$ 25% w/w TMAH
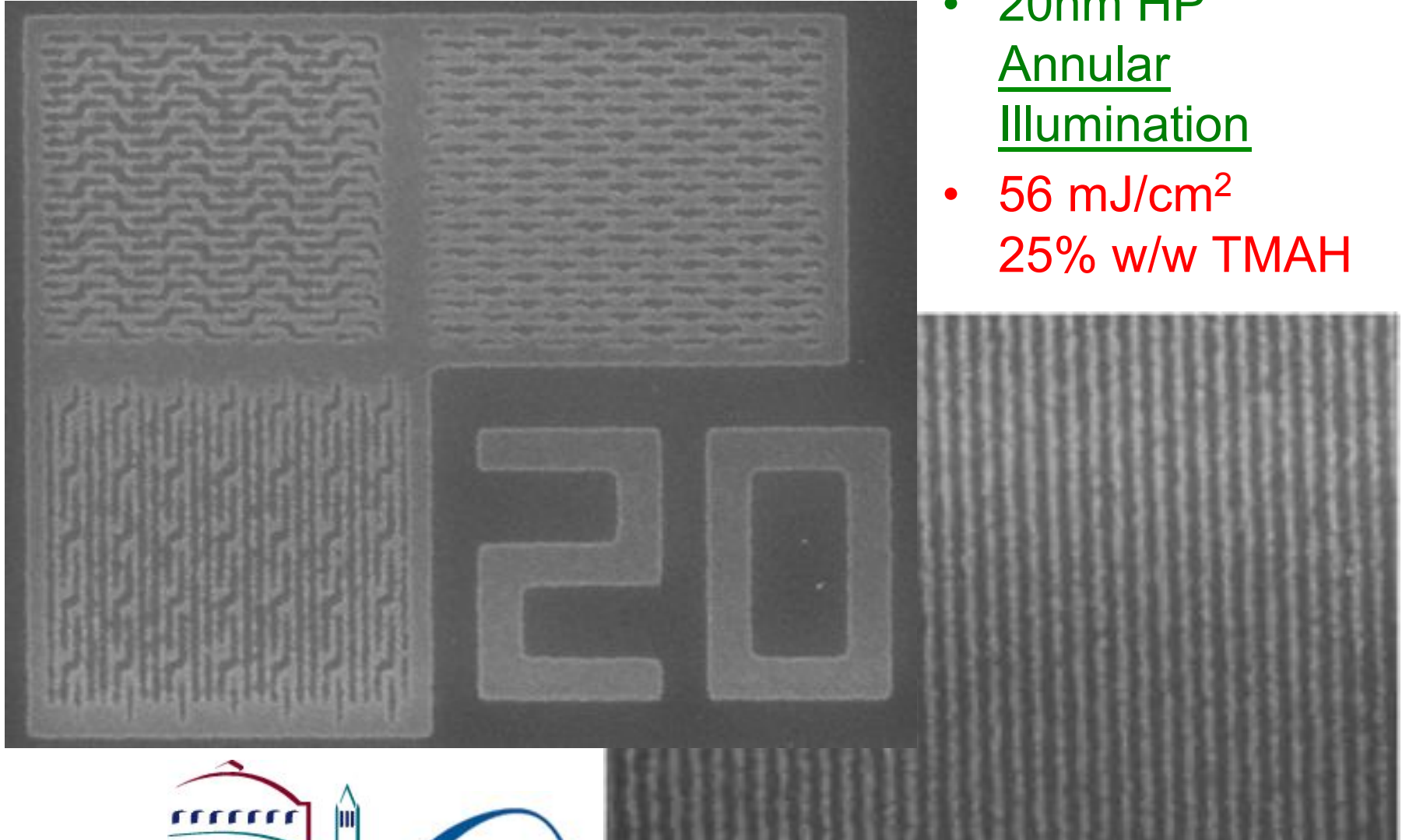
# Alternate Developer

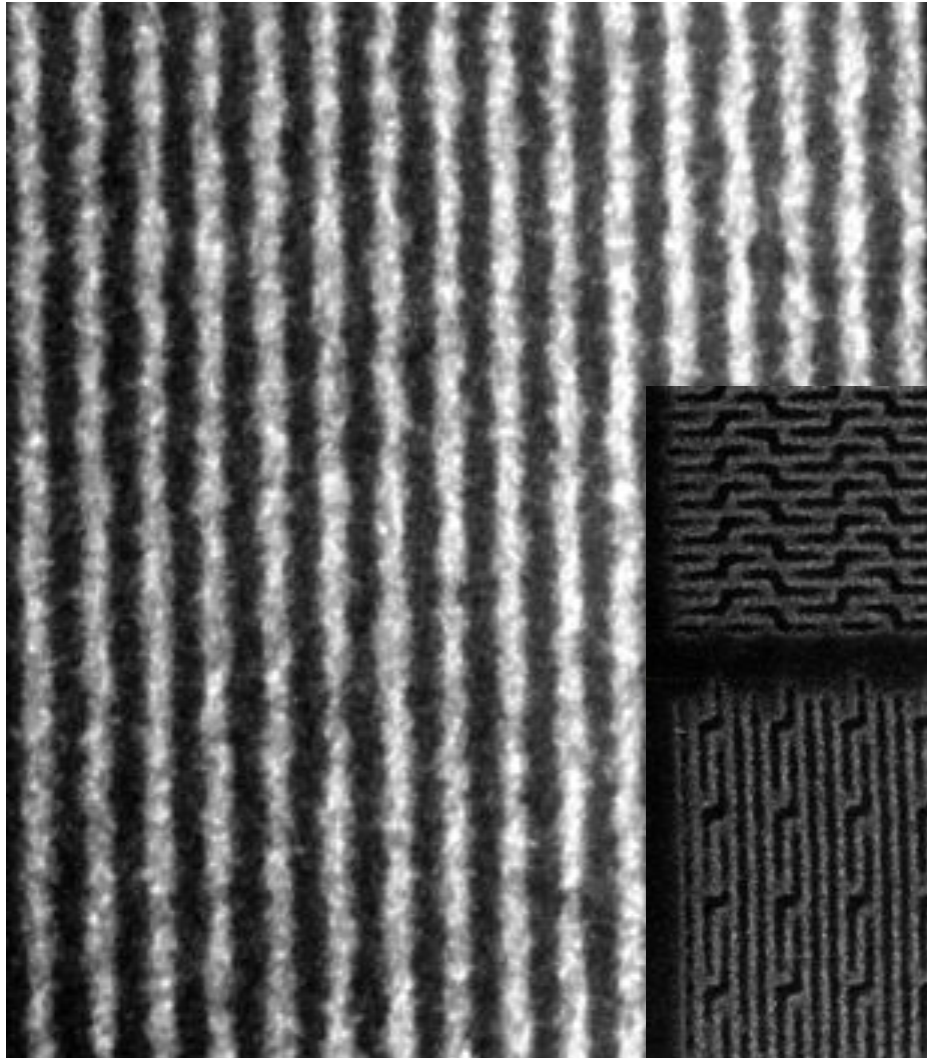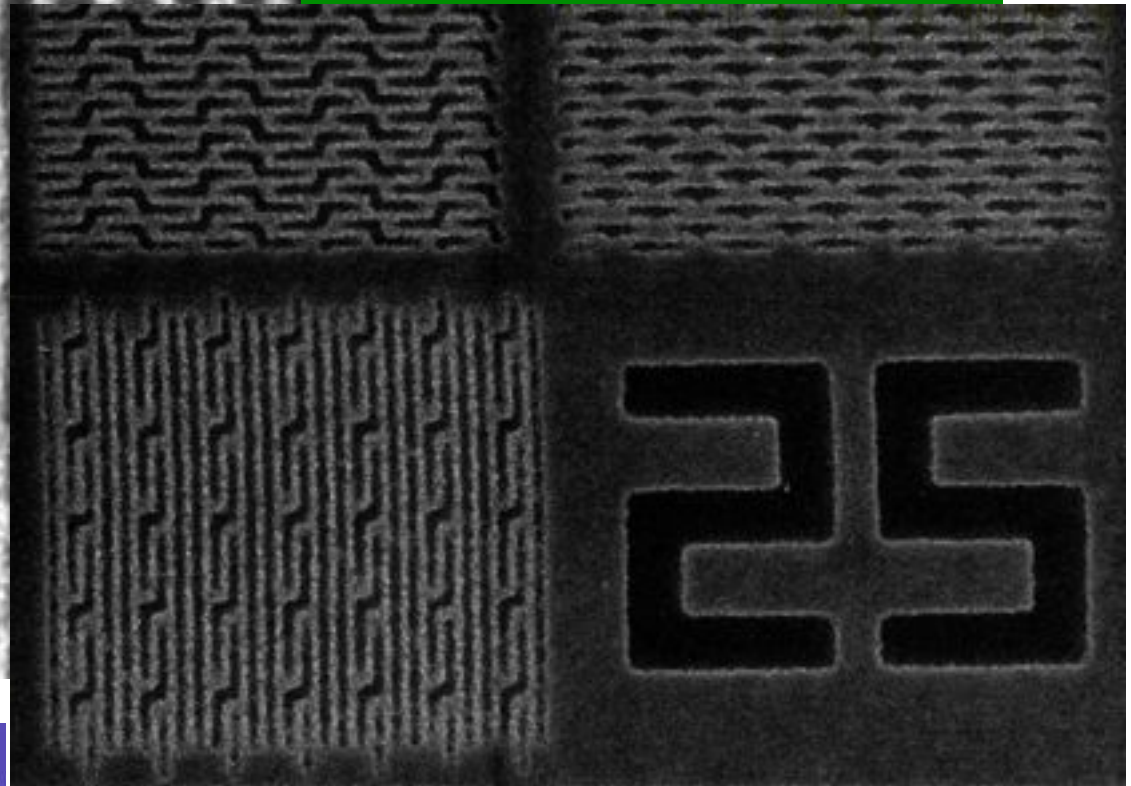Annular Illumination
65 mJ/cm$^2$
35% w/w TEAH
(Tetraethyl ammonium hydroxide)

# Process Development for Increased Sensitivity



- 24 hp lines and 25 hp SRAM cell
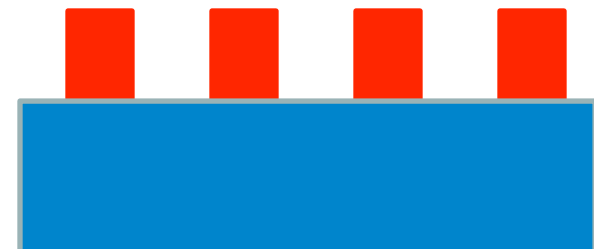- 35% TEAH
- **24 mJ/cm$^2$**



Courtesy Hiroki Nakagawa, Mark Slezak, JSR Micro

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# Pattern Collapse Mitigated
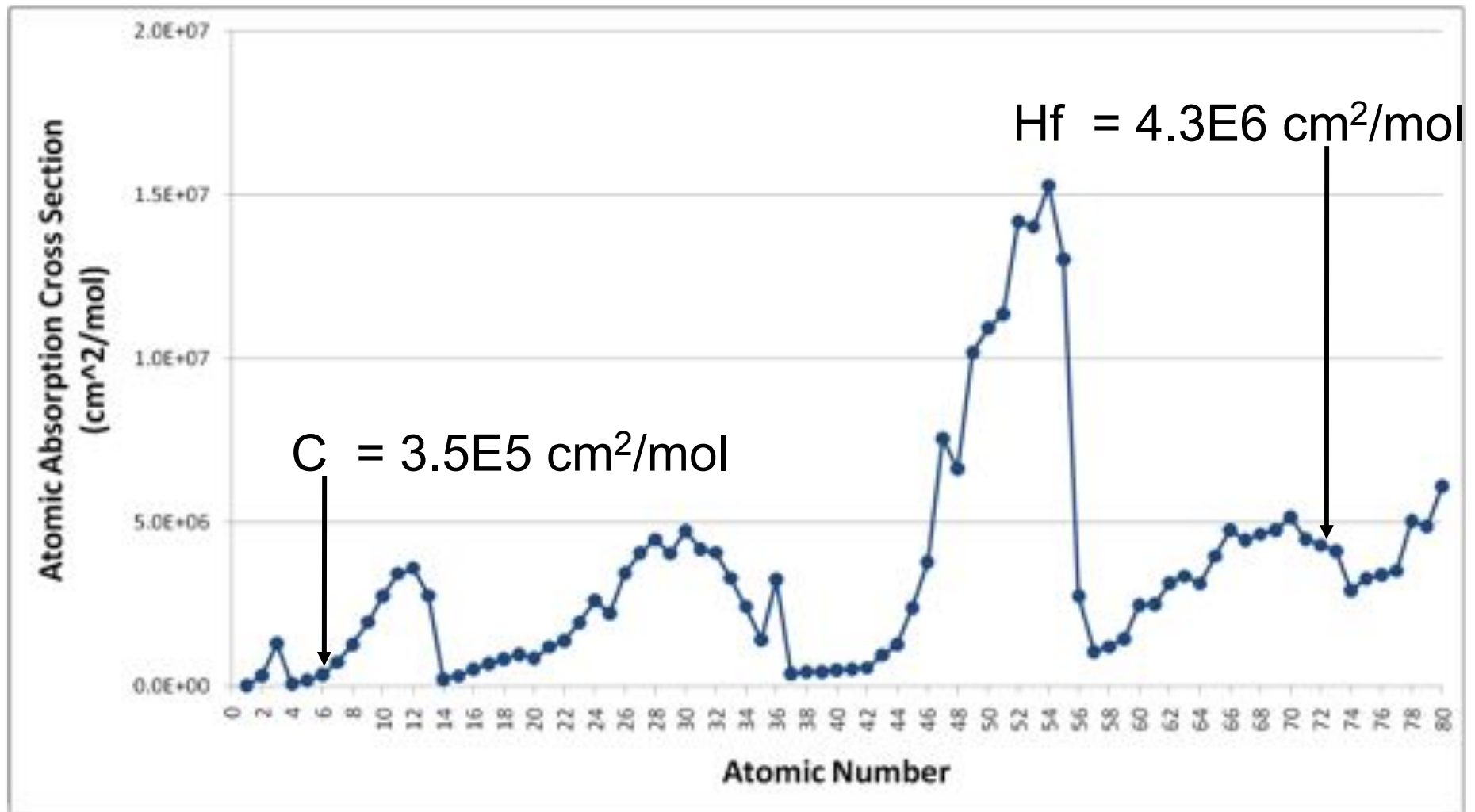
## Resist Film Thickness Driven by EUV Absorbance and Etch

p-CAR
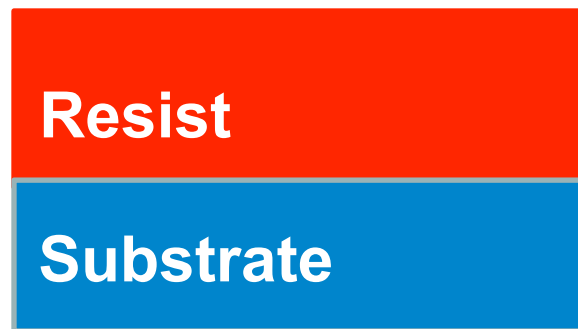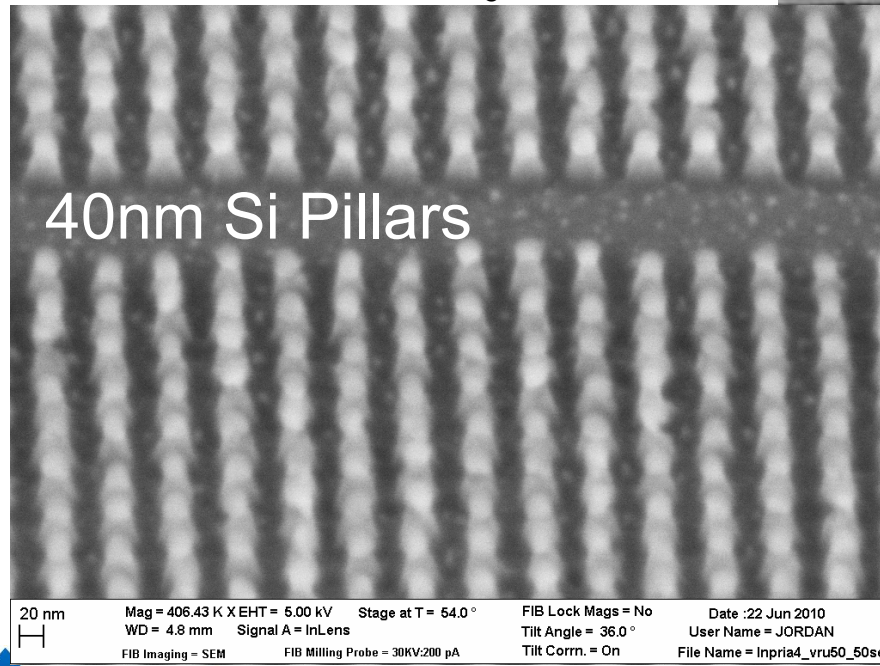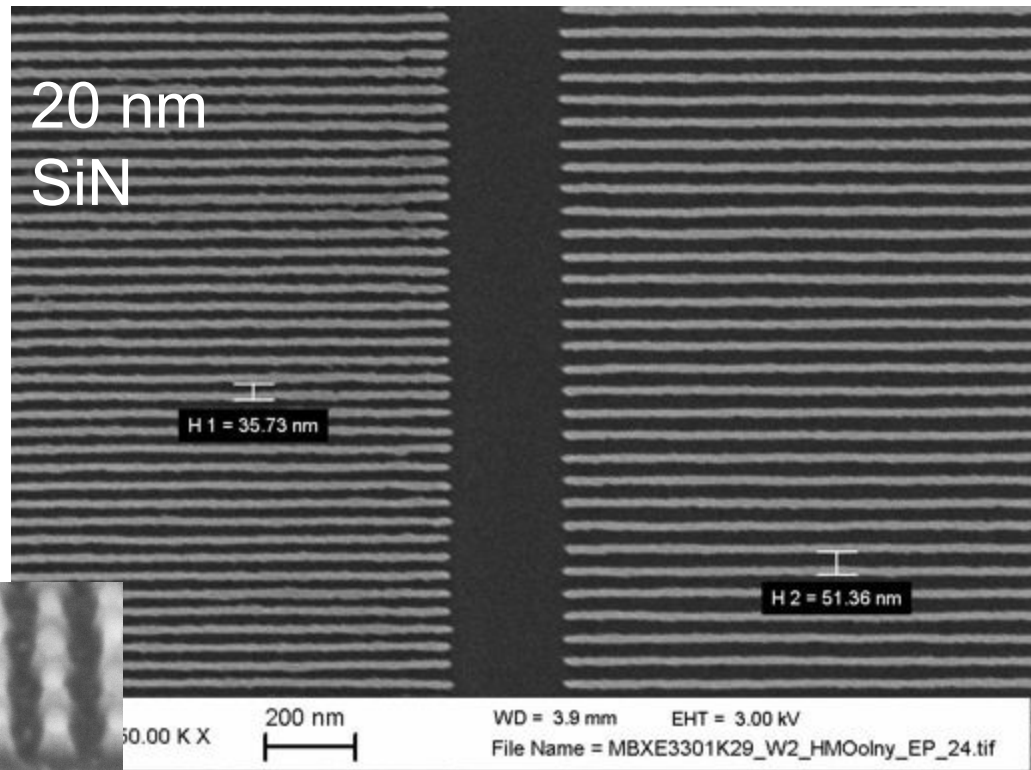
Metal
Oxide
Resist

# EUV Photoabsorption Cross Section

# Pattern Transfer

**Direct transfer using resist as mask**

18 HP

25 HP

20 nm SiN

H 1 = 35.73 nm

H 2 = 51.36 nm

$SF_6$ based RIE

200 nm

50.00 K X

WD = 3.9 mm    EHT = 3.00 kV
File Name = MBXE3301K29_W2_HMOolny_EP_24.tif

40nm Si Pillars

Courtesy;
Markus Brink
Ernst Kratschmer
Sebastian Engelmann
Michael Guillorn
IBM

| 20 nm | Mag = 406.43 K X | EHT = 5.00 kV | Stage at T = 54.0 ° | FIB Lock Mags = No | Date :22 Jun 2010 |
| | WD = 4.8 mm | Signal A = InLens | Tilt Angle = 36.0 ° | User Name = JORDAN |
| | FIB Imaging = SEM | FIB Milling Probe = 30KV:200 pA | Tilt Corrn. = On | File Name = Inpria4_vru50_50se |

25 HP

Courtesy; Jordan Katine,
Hitachi Global Storage Technologies

inpria

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# Outgassing Tests



$H_2O$ ~6.5e+15 molec cm$^{-2}$

$O_2$ ~3.5e+15 molec cm$^{-2}$
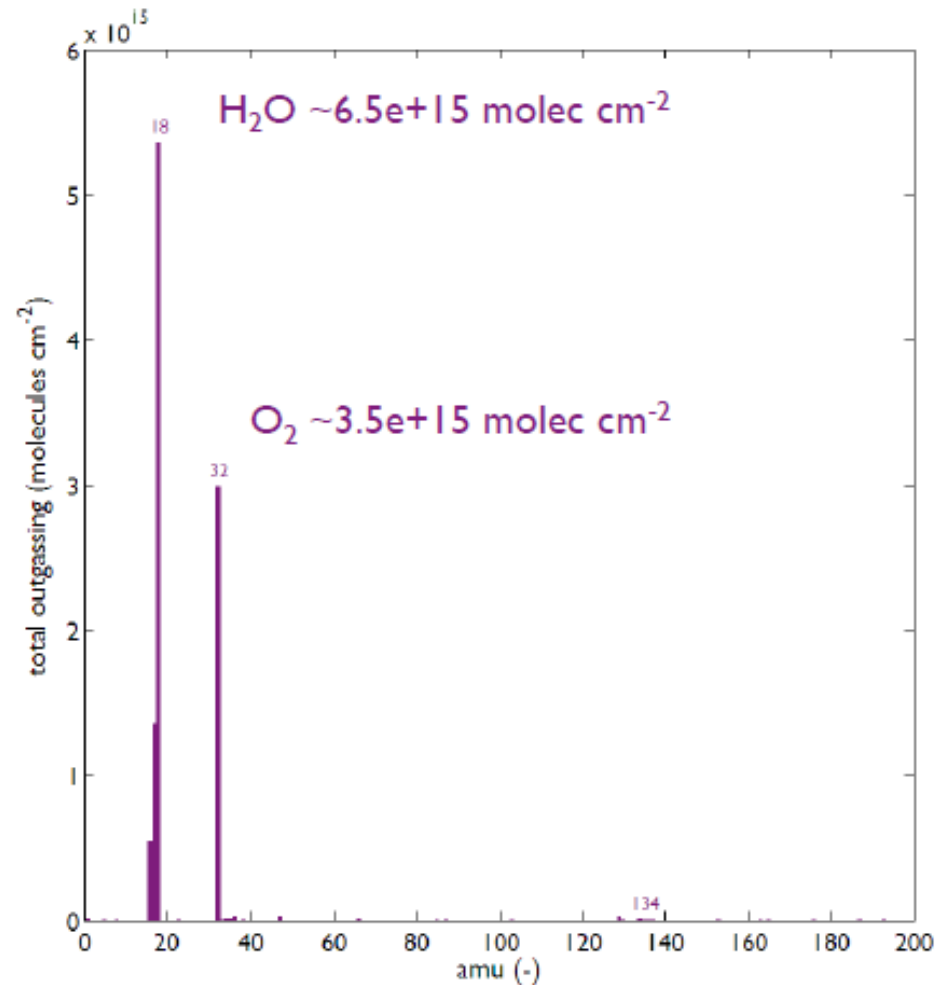
$H_2O$ and $O_2$ outgassing result in (carbon) contamination removal !



Courtesy Roel Gronheid, Ivan Pollentier, IMEC

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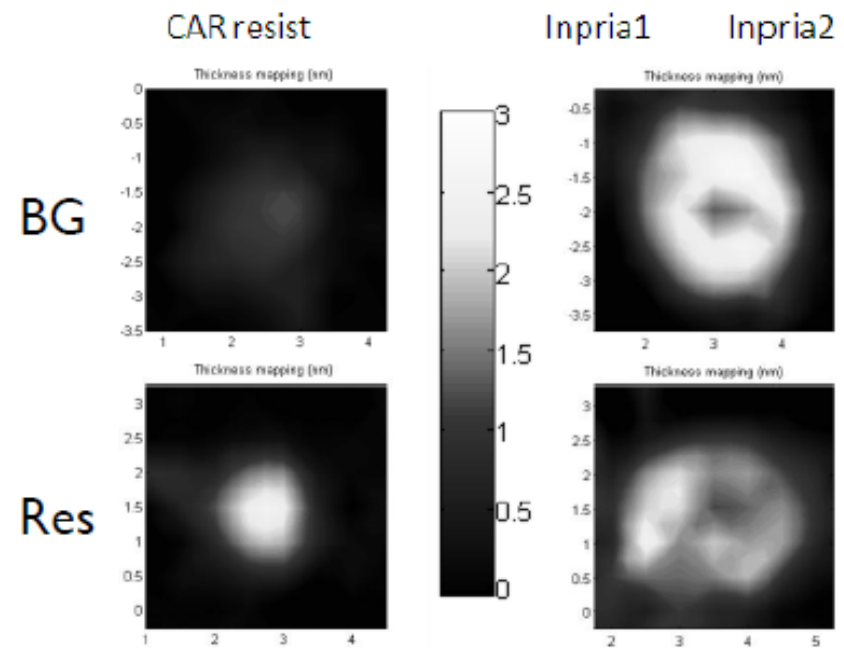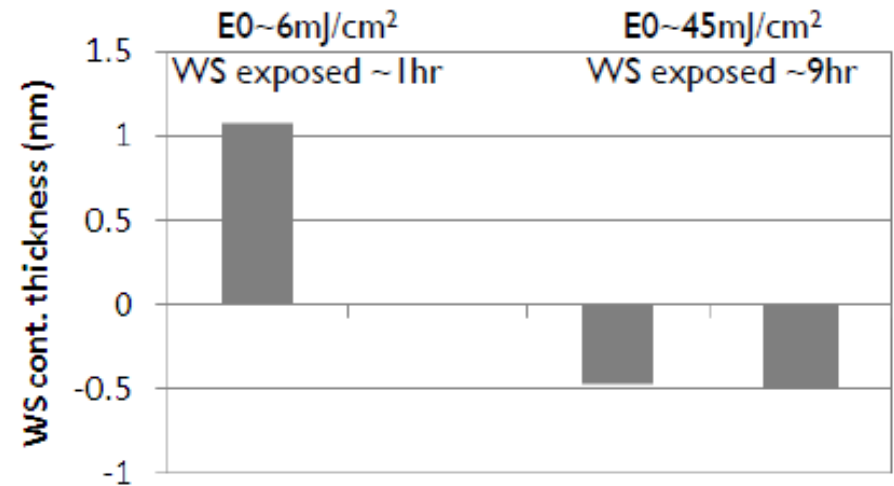
# Conclusions

- Inpria's metal oxide resist yields unprecedented EUV pattern fidelity with no acid blur
    - <16nm hp demonstrated
    - 2D imaging: 20nm SRAM cell printed on 0.3NA MET
    - Capable of very low LWR
- Ultrathin imaging mitigates pattern collapse
- Completely inorganic
    - Demonstrated very low outgassing relative to scanner specs

- Development underway for improved sensitivity, alternate developer and underlayer integration

# Acknowledgments